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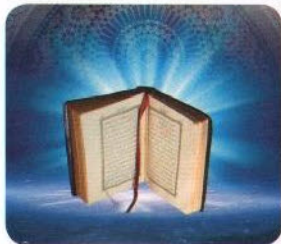
*The people who contemplate,
my family,
my venerable parents
and my wife
(Who prayed all life for my success).*


May Allah Bestow His Mercy upon them.



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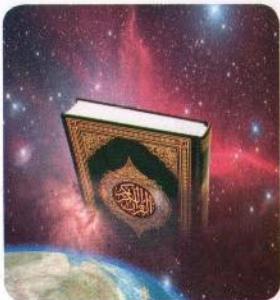
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Preface

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

*In the name of Allah, Most Gracious,
Most Merciful*

The Holy Qur'an is the eternal Message of Allah to mankind of the worlds, revealed to Muhammad, the Messenger of Allah (P.B.U.H), more than fourteen hundred years ago. This Book deals with man's code of conduct and true life style from cradle to grave in particular and the whole universe in general. The Holy Qur'an solves all the problems of mankind in this world, and the Hereafter, because it enshrines all the rules and regulations for our guidance and instructions.

﴿وَعَلَّمَ آدَمَ الْأَسْمَاءَ كُلَّهَا﴾

(1)- "And He (Allah) taught Adam the names of all things" [Sura Al-Baqara, Ch.2, Verse 31]

﴿عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ﴾

(2)- "And He (Allah) taught man that which he knew not." [Sura Iqraa, Ch.96, Verse 5]

From these verses it is clear that Allah, the Almighty, revealed to Adam (P.B.U.H) all knowledge of creation of the universe. As Man is the progeny of Adam (P.B.U.H), therefore, the knowledge of everything such as Physics, Astrophysics, Metaphysics, Chemistry, Biology, Genetics etc., is well written on the genes of Man.

The man is made up of about trillion of cells. It has been discovered that every human cell is composed of 46 chromosomes, 23 from female side and 23 from male side. Chromosomes carry a set of instructions called genes. The genetic writing called Genome is the pre-programmed picture of an individual's personality and destiny. Whenever, a scientist makes a scientific discovery, it is not external discovery but is already

present in his genome. It means that without the guidance of Allah (Subhanhu) the discovery is not possible. Hence, Allah, the Almighty, guides scientists, irrespective of their colour, caste, creed, and religion, because research work is the fundamental right of every human being.

The Holy Qur'an clearly establishes the fact that science and the Qur'an are not opposed to each other because the Holy Qur'an is full of scientific explications.

The whole structure of the universe is full of His Signs but only men of knowledge (scientists, philosophers etc.) observe and understand them. In this regard, the Holy Qur'an says:



(3)- “And He (Allah) has subjected to you, as from Him, all that is in the Heavens and on the Earth: behold; in that are the Signs indeed for those who reflect.” [Sura Jāthiya, Ch.96, Verse 5]

﴿اِنَّ فِيْ خَلْقِ السَّمٰوٰتِ وَالْاَرْضِ وَاٰخَتِلَافِ اللَّيْلِ وَالنَّهَارِ لَاٰيٰتٍ لِّاُولِي الْاَلْبَابِ﴾

(4)- “Behold! In the creation of the Heavens and the Earth, and the alternation of the Night and Day, certainly there are Signs for men of understanding, [Sura Āl-‘Imrān, Ch.3, Verse 190]

The verses (3-4) invite the believers to observe and contemplate upon all that is in the universe. In other words, the Muslims must do research work in all fields of science as they did in the early epoch of the Islamic history.

In this book I have made an attempt to introduce the relationship between the Holy Qur'an and Astrophysics to the science-students in particular and science-conscious people in general. In

compiling this book I have consulted a number of books and journals on Physics as well as on religion. The list of references has been given at the end of the book. The verses of the Holy Qur'an and topics of Astrophysics (common to both areas) have been brought together in the form of separate chapters. My own comments on various points in this regard are in the form of possibilities and speculations. Allah, the Almighty, knows the best.

The experience of 36 years, 5 months and 12 days gained in teaching Physics at F.Sc., B.Sc., and Quantum Mechanics at M.Sc. level has been used in compilation of this book. Every endeavour has been made that all the chapters must contain up-to-date scientific knowledge.

It will not be justified, if I do not mention the late my father in law Ch. Muhammad Iqbal and Professor Sakhawat Ali (May Allah bless their souls and rest in Heaven (Jannat)). My father in law left bequest of the Holy Qur'an (English Translation and Commentary Edition 1937, by A. Yusuf Ali) to be gifted to me. Prof. Sakhawat Ali gave me the book “A BRIEF HISTORY OF TIME,” Edition 1992, by STEPHEN W. HAWKING and encouraged me to write the book “Astrophysics and the Holy Qur'an”. I am also very thankful to Mr. Khurram Sajjad who gifted me the book “Qur'anic Prism” 5th Edition, 2007 by Engineer Abdul Hakeem Malik. I made ample use of them in the compilation of this book.

I am very grateful to Prof. Dr. Abdul Rashid Khan, Ex-Principal, Govt. College of Commerce, Faisalabad, Hafiz Prof. Dr. Muhammad Din Qasmie (Retired), Dr. Abdus Samie, Prof. Malik Muhammad Aslam, Ex-Chairman, Department of English, G. C. University, Faisalabad and Hafiz Qari Asif Raza, Lecturer G. C. University, Faisalabad for many useful suggestions, guidance and help in preparing the draft of

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May Allah, the Almighty accept my endeavour in this regard and I pray that this book may become the source of enlightenment for the readers. May Allah forgive my shortcomings and sins (Aameen!).

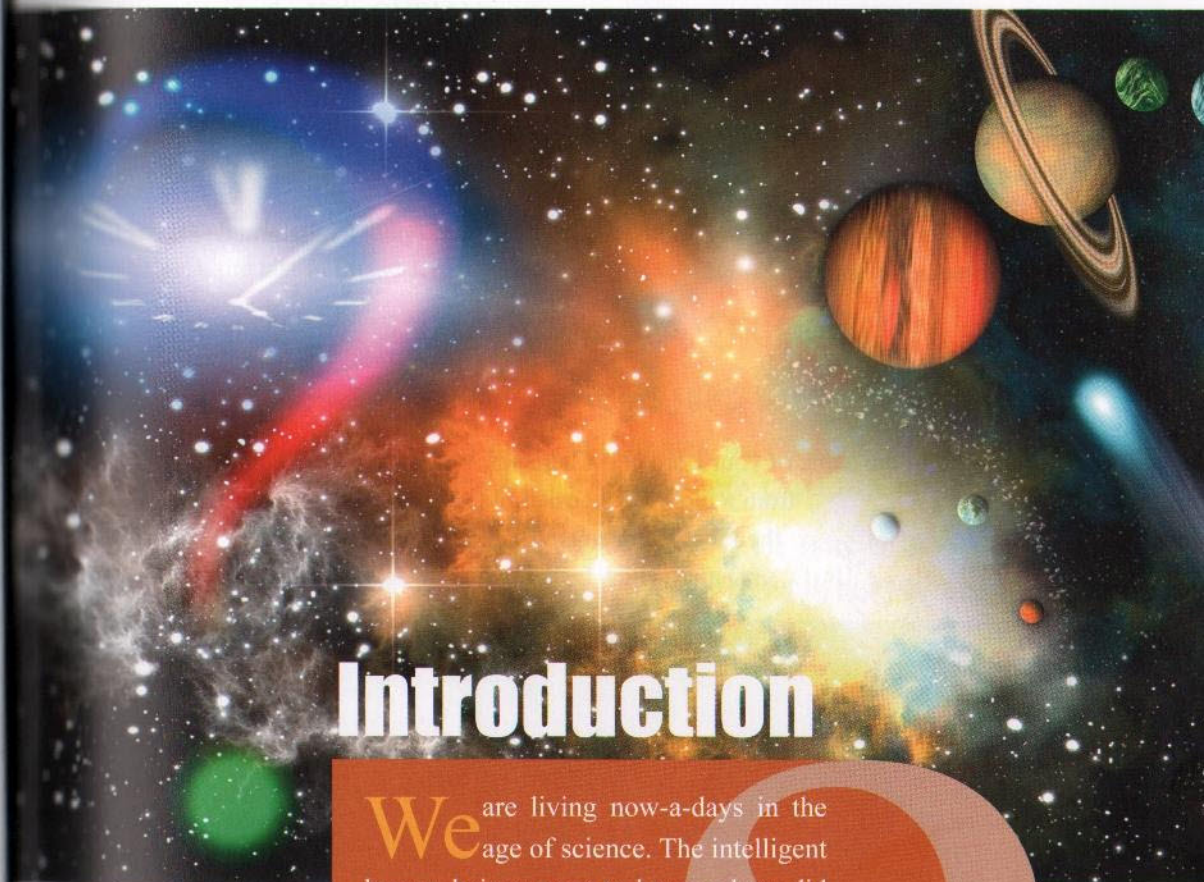
Criticism and suggestions for improvement of this book will be welcome and highly appreciated.



Prof. Abdul Rashid Khan

May, 2012

Note: The pictures used in this book are computer generated and are subject-specific.



Introduction

We are living now-a-days in the age of science. The intelligent human beings want to know where did they come from? Where did the universe come from? Will the universe come to an end, if so, how? Is the universe static or dynamic, if dynamic, is it expanding or contracting? What is time? When was it started? Will it come to an end? What are Black Holes? What are the forces of Nature? What is the smallest piece of matter? What is the status of man in the universe? Are there ultimate limits for human beings to know about something?

The majority of people especially in the third world are unable to answer these questions. When they are asked such questions, most of them answer with a shrug or with a vague and ambiguous knowledge. On the basis of Holy QUR'AN as well as scientific knowledge, I have tried my level best to answer these questions in this book **"Astrophysics and the Holy QUR'AN"**.

In the very first verse of the Holy QUR'AN revealed to Prophet Muhammad (PBUH), he was directed to read.

﴿أَقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ ۝١ خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ ۝٢ اقْرَأْ وَرَبُّكَ الْأَكْرَمُ ۝٣﴾

الَّذِي عَلَّمَ بِالْقَلَمِ ۝٤ عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ ۝٥﴾

"1- Read! In the name of your Lord and Cherisher, Who created 2- Created man from a clot of congealed blood: 3- Read! and your Lord is the most Bounteous, 4-Who taught by the pen, 5- Taught man that which he knew not." [Sura Alaq, Ch.96, Verse 1-5]

The importance of reading, writing and acquiring knowledge has been explained in this verse in a very forceful and direct manner. It is obligatory for every Muslim to obey Lord's commandments. The importance of knowledge is so much emphasized in Islam that the Prophet Muhammad (PBUH) had the constant prayer:

﴿رَبِّ زِدْنِي عِلْمًا﴾

"O my Lord! Advance me in knowledge." [Sura Tā-Hā, Ch.20, Verse 114]

The Prophet Muhammad (PBUH) announced that it is the obligation (sacred duty) of every Muslim (man and woman) to seek knowledge.

The human knowledge can be divided into two types:

- (i) Revealed knowledge
- (ii) Acquired knowledge

The source of revealed knowledge is Wahi or Revelation from Allah, the Almighty. Allah had passed on the revealed knowledge to the mankind through His prophets or messengers (peace be upon them).

According to the Holy QUR'AN:

﴿وَلَقَدْ بَعَثْنَا فِي كُلِّ أُمَّةٍ رَسُولًا أَنِ اعْبُدُوا اللَّهَ وَاجْتَنِبُوا الطَّاغُوتَ ۝﴾

"And we have sent a messenger, in every community saying, "Serve Allah, and keep away from evil" [Sura Nahl, Ch. 16, Verse 36]

The final revelation of this series is the Holy QUR'AN revealed to Prophet Muhammad (PBUH), the last in the series of Prophets.

According to the Holy QUR'AN:

﴿مَا كَانَ مُحَمَّدٌ أَبَا أَحَدٍ مِنْ رِجَالِكُمْ وَلَكِنْ رَسُولَ اللَّهِ وَخَاتَمَ النَّبِيِّينَ ۝﴾

"Muhammad is not the father of any of your men, but (he is) the Messenger of Allah and the seal (last) of the Prophet" [Sura Al-Ahzāb, Ch. 33, Verse 40]

Since the revelation preserved in its original form is the Holy QUR'AN only, in accordance with the commitment of Allah, the Almighty, for its protection.

According to the Holy QUR'AN:

﴿إِنَّا نَحْنُ نَزَّلْنَا الذِّكْرَ وَإِنَّا لَهُ لَحَافِظُونَ ۝﴾

"We have, without doubt, revealed the Reminder (Message); and We will surely be the Guardian." [Sura Al-Hijr, Ch. 15, Verse 9]

﴿إِنَّ الَّذِينَ كَفَرُوا بِالذِّكْرِ لَمَّا جَاءَهُمْ وَإِنَّهُ لَكِنْتُ عَزِيْزٌ ۝١ لَا يَأْتِيهِ الْبَاطِلُ

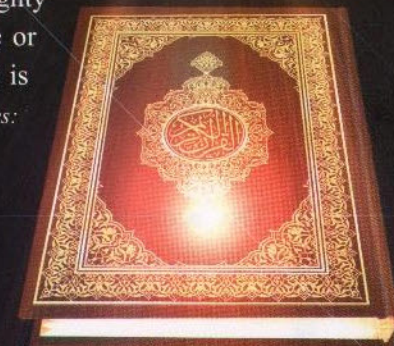
مِنْ بَيْنِ يَدَيْهِ وَلَا مِنْ خَلْفِهِ تَنْزِيلٌ مِنْ حَكِيمٍ حَمِيدٍ ۝٢﴾

"41- Those who reject the Message (Reminder) when it comes to them, should know that in fact, it is a Mighty Book. 42- No falsehood can approach it from before or from behind it: It is a revelation from the One, Who is Wise and Praise Worthy." [Sura Hā-Mim Sajda, Ch. 41, Verses: 41-42]

﴿إِنَّهُ لَقُرْآنٌ كَرِيمٌ ۝٧٧ فِي كِتَابٍ مَكْنُونٍ ۝٧٨ لَا يَمَسُّهُ

إِلَّا الْمُطَهَّرُونَ ۝٧٩ تَنْزِيلٌ مِنْ رَبِّ الْعَالَمِينَ ۝﴾

"77- Certainly it is the most honourable QUR'AN,



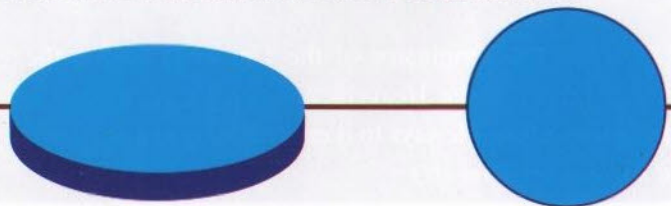
Old View about the Universe:

The ancient people believed that the Earth was a flat plate supported on the back of the giant tortoise. But as long as 340 B.C., the Greek Philosopher, Aristotle believed that the Earth was not a flat plate but a round sphere.

He gave the following good arguments to support his view about the Earth as a round sphere:

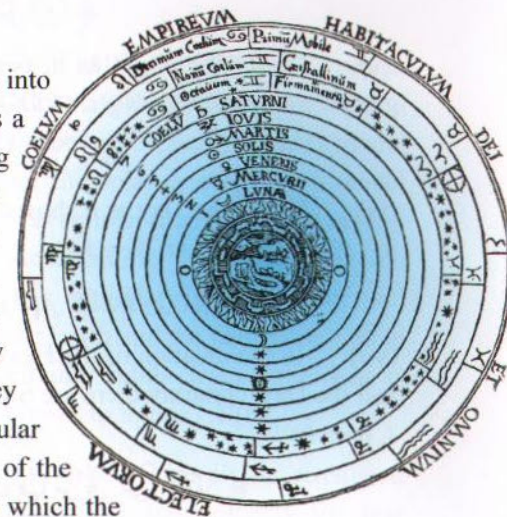
- (1) He realized that eclipses of the Moon were produced by the Earth coming between the Sun and the Moon. The Earth's shadow on the Moon is always round, which is possible only if the Earth is spherical and not a flat plate.
- (2) The Greeks observed during their travels that the North Star appeared lower in the sky when viewed in the south region than in the north region. From the difference in the apparent position of the North Star in Egypt and Greece, Aristotle estimated the distance around the Earth which was about twice the currently accepted figure (40192 km).
- (3) Apart from Aristotle, the ancient Greek sailors had the argument that the Earth must be spherical because one first sees the sails of a ship coming over the horizon and later sees the body of a ship.

According to Aristotle, the Earth was stationary and the Sun, the Moon, the planets and the stars moved in circular orbits around the Earth. He further added that the whole universe was built in seven spheres with the Earth as the centre. Hence, according to Aristotle, the Earth was considered as the centre of the universe.



Ptolemaic Model:

Ptolemy in 2nd century elaborated the above idea into a complete cosmological model. This model was a geocentric model for the solar system. According to this model, the Earth was stationary at the centre surrounded by eight spheres that carried the Moon, the Mercury, the Venus, the Sun, the Mars, the Jupiter and the Saturn. The outermost sphere carried the so-called fixed stars, which always stay in the same positions relative to each other but they rotate together across the sky. Because simple circular orbits could not explain the complicated motions of the planets, Ptolemy used the concept of epicycles, in which the planets themselves move on smaller circles such that their centers move around the circles centered on the Earth as shown in Figure 1.1 (a).



In Ptolemaic model, it was never made very clear what lay beyond the last sphere but it was adopted by Christian church because the picture of the universe was in accordance with Scripture, for it had the greater advantage that it allowed lots of room outside the sphere of fixed stars for Heaven and Hell.

According to the Holy Qur'an:

﴿أَلَمْ تَرَ أَنَّ اللَّهَ يُولِجُ اللَّيْلَ فِي النَّهَارِ وَيُولِجُ النَّهَارَ فِي اللَّيْلِ﴾

- (i) "Do not you see that Allah merges Night into Day and He merges Day into Night." [Sura Luqmān, Ch 31, Verse 29]

﴿خَلَقَ السَّمَوَاتِ وَالْأَرْضَ بِالْحَقِّ يُكَوِّرُ اللَّيْلَ عَلَى النَّهَارِ وَيُكَوِّرُ النَّهَارَ عَلَى اللَّيْلِ﴾

- (ii) "He created the Heavens and the Earth in true (proportions): He makes the Night overlap the Day, and the Day overlap the Night." [Sura Zumar, Ch 39, Verse 5]

﴿إِنَّ فِي اخْتِلَافِ اللَّيْلِ وَالنَّهَارِ وَمَا خَلَقَ اللَّهُ فِي السَّمَوَاتِ وَالْأَرْضِ لَآيَاتٍ لِّقَوْمٍ يَعْقِلُونَ﴾

- (iii) "Verily, in the alternation of the Night and the Day, and in all that Allah has created, in the Heavens and the Earth, are Signs for those who fear Him." [Sura Yūnus, Ch 10, Verse 6]

﴿يُعْشَى اللَّيْلَ النَّهَارَ يَطْبُهُ حَيْثَا﴾

- (iv) "He draws the Night as a veil over the Day, each seeking the other in rapid succession." [Sura A'rāf, Ch 7, Verse 54]

Beginning of the Universe:

The expansion of the universe shows that at earlier times the objects (galaxies, stars and the planets) would have been closer together. In fact, there was a time, 13.7 billion years ago (according to standard model of cosmology), when all the objects were exactly at the same place and therefore, the density of the universe was infinite. This discovery finally suggested that there was a Big Bang which resulted in the beginning of the universe. In other words, Allah, the Almighty, created the universe at the instant of Big Bang. According to science, the time had a beginning at the Big Bang and the earlier time would not be defined. In other words, the universe was created at time $t=0$.

Now-a-days it is believed that the universe was created by Allah from "NOTHING". We know that matter/antimatter can be created from a perfect vacuum analogous to the pair production of a matter/antimatter from energy (energetic photon).

According to the Holy Qur'an:

﴿ثُمَّ اسْتَوَىٰ إِلَى السَّمَاءِ وَهِيَ دُخَانٌ فَقَالَ لَهَا وَلِلْأَرْضِ ائْتِيَا طَوْعًا أَوْ كَرْهًا قَالَتَا أَتَيْنَا طَائِعِينَ﴾

"Then He turned to the Heaven, when it was smoke: and said to it and to the Earth: "Come both of you, willingly or unwillingly". They said: "We do come (together) in willing obedience." [Sura Fussilat, Ch. 41, Verse 11]

This verse of the Holy Qur'an shows that the initial matter was in the form of gaseous state which was to constitute the Heaven and the Earth, was ordered by Allah to get asunder (apart).

Dr. Alfred Kroner is one of the renowned geologists of the world. He is Professor of Geology and Chairman of Department of Geology at the Institute of Geosciences, Johannes Gutenberg University, Mainz, Germany. He said, "I think it is almost impossible for Muhammad (PBUH) who could have known about things like the common origin of the universe more than 1400 years ago, because scientists have only found out this fact within last few years, with very complicated and advance technological methods. He also said: somebody who did not know something about the nuclear physics, more than 1400 years ago, could not, I think, be in a position

to give from his own mind, that the Earth and the Heavens had the same origin. It means that the Qur'an is the revelation from Allah, the Creator of this universe.

﴿أَوَلَمْ يَرِ الَّذِينَ كَفَرُوا أَنَّ السَّمَوَاتِ وَالْأَرْضَ كَانَتَا رَتْقًا فَفَتَقْنَاهُمَا﴾

"Do not the unbelievers see that the Heavens and the Earth were joined together (as one unit of creation), before We clove them asunder?" [Sura Anbiya, Ch.21, Verse 30]

﴿إِنَّ رَبَّكُمُ اللَّهُ الَّذِي خَلَقَ السَّمَوَاتِ وَالْأَرْضَ فِي سِتَّةِ أَيَّامٍ﴾

"Your Guardian-Lord is Allah, Who created the Heavens and the Earth in six Days, (periods)." [Sura A'raf, Ch.7, Verse 54]

﴿قُلْ أَنتُمْ لَكُمْ كُفْرُوكُمْ بِالَّذِي خَلَقَ الْأَرْضَ فِي يَوْمَيْنِ﴾

"Say: Is it that you deny Him Who created the Earth in two Days, (periods)." [Sura Fussilat, Ch. 41, Verse 9]

﴿إِنَّا كُلَّ شَيْءٍ خَلَقْنَاهُ بِقَدَرٍ ۖ وَمَا أَمْرُنَا إِلَّا وَجِدَةٌ كَلَمْحٍ بِالْبَصَرِ ۖ﴾

49- "Verily, all things We have created in proportion and measure. 50- And Our command is but a single (Act), like the twinkling of an eye." [Sura Qamar, Ch. 54, Verse 49-50]

﴿إِنَّمَا قَوْلُنَا لِشَيْءٍ إِذَا أَرَدْنَاهُ أَنْ نَقُولَ لَهُ كُنْ فَيَكُونُ﴾

"For to anything, which We intend, We say to it only. "Be", so it is." [Sura Nahl, Ch. 16, Verse 40]

﴿يَدْعِي السَّمَوَاتِ وَالْأَرْضِ وَإِذَا قَضَىٰ أَمْرًا فَإِنَّمَا يَقُولُ لَهُ كُنْ فَيَكُونُ﴾

"To Him (The Originator of the Universe) is due the primal origin of the Heavens and the Earth: when He decrees an affair, He says to it only "BE", and it is." [Sura Al-Baqara, Ch.2, Verse 117]

From the above verses, it is clear that it is the "BE" which includes the complete destiny of universe starting from Big Bang to the Big Crunch (i.e. the end of the universe.)

Expanding Universe And The Holy Qur'an



﴿وَالسَّمَاءَ بَنَيْنَاهَا بِأَيْمٍ وَإِنَّا لَمَوْسِعُونَ﴾

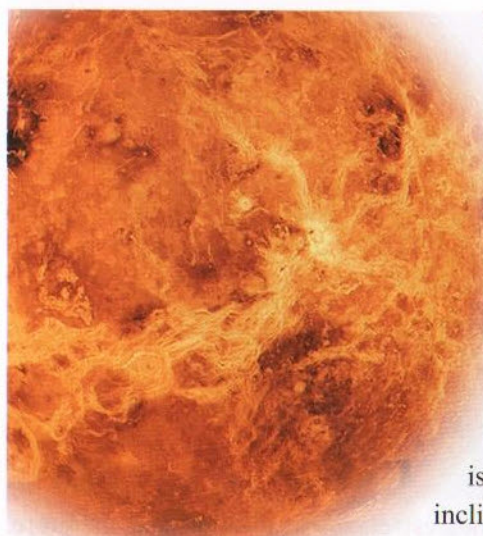
“With power and skill did We construct the Heaven: For it is We Who create the vastness of Space.” [Sura Zāriyāt, Ch.51, Verse, 47]

THE STARS

If we look at the sky on a clear, moonless night, the brightest heavenly bodies we see are likely to be the planets Venus, Mars, Jupiter and Saturn. There are very large numbers of stars which are just like our own Sun but much far away from us. Some of these stars appear to change very slightly their positions relative to each other as the Earth orbits around the Sun, because they are comparatively near to us. As the Earth revolves around the Sun, we see them from different positions against the background of more distant stars. The nearer they are, the more they appear to move. The nearest star, called the Proxima Centauri, is 4.3 light-years away from us. In other words the light from it takes 4.3 years to reach the Earth. The distance light travels with speed of 3×10^8 km/sec in one year is about 9.5 trillion kilometers and is called a light-year. Thus the nearest star is about 40.85 trillion kilometers away from us. Most of other stars that are visible to the naked eye lie within a few hundred light-years from us. Our Sun for comparison is only eight-minutes away from us.

The energy is generated in stars by the fusion process. This energy generated tries to explode the star, whereas the gravity of the star tries to implode (contract) it. Equilibrium between these explosive and implosive forces keeps the star going on. If the explosive force increases, the star ends as a Nova or Super-Nova and if implosive force increases, the star collapses as a neutron star or a black hole, depending upon the size of the star.

At night time the stars have been of great use for travel and navigation for locating the position on the Earth. The navigators in the northern region use the North Star, while in the southern region they use other stars for determining their latitude.



The Venus: (The Roman goddess of love and beauty)

The Venus is a planet and it occupies second position among the eight planets revolving around the Sun. The mean distance of the Venus from the Sun is 1.08×10^8 km. Its period of revolution about the Sun is 0.615 year and its orbital speed is 35.0 km/s.

It completes one rotation about its own axis in 243 days and the sense of rotation is opposite to that of the orbital motion. The inclination of its orbit to Earth's orbit is 3.39°

and inclination of its axis to its orbit is 2.6° . Its equatorial diameter is 12,100 km. The mass of Venus is 0.815 Me. And its mean density is 5.20 g/cm^3 . The surface gravity at its equator is 8.60 m/s^2 and the escape velocity is 10.3 km/s. There is no known satellite orbiting around the Venus.



Figure 3.5 (Venus)

The Mars: (The Roman god of War)

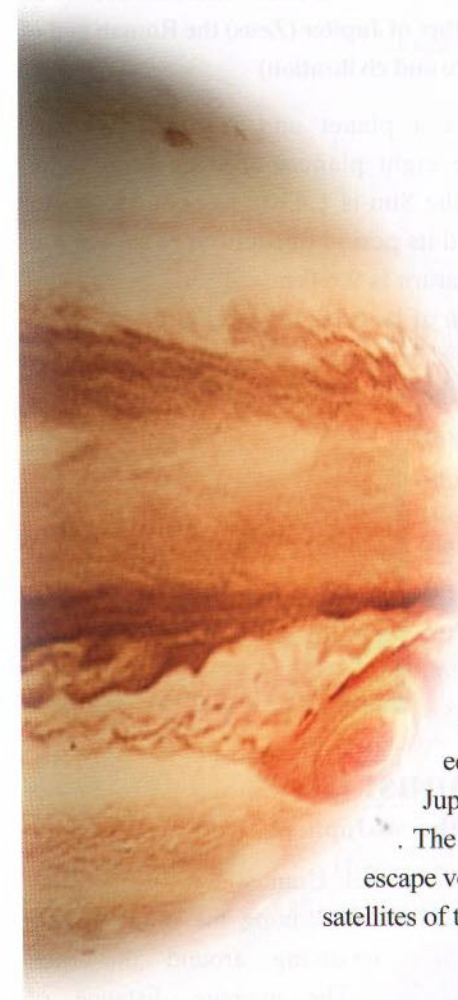
The Mars is a planet and it occupies fourth position among the eight planets revolving around the Sun. The mean distance of the Mars from the Sun is 2.28×10^8 km. Its period of revolution about the Sun is 1.88 years and its orbital speed is 24.1 km/sec. The period of rotation of Mars about its own axis is 1.03 days. The inclination of axis to its orbit



is 24.0° and the inclination of its orbit to Earth's orbit is 1.85° . Its equatorial diameter is 6,790 km. The mass of Mars is 0.107 Me and its mean density is 3.95 g/cm^3 . Its surface gravity at its equator is 3.72 m/s^2 . The escape velocity is 5.0 km/s. There are two known satellites orbiting around the Mars.



Figure 3.6 (Mars)



The Jupiter: (The Roman King of gods identified with Greek Zeus)

The Jupiter is a planet and it has fifth position among the eight planets revolving around the Sun. The average distance of the Jupiter from the Sun is 7.78×10^8 km. It completes one revolution about the Sun in 11.9 years and its orbital speed is 13.1 km/s. Its period of rotation about its own axis is 0.409 days. The inclination of its axis to its orbit is 3.08° and the inclination of its orbit to Earth orbit is 1.30° . Its equatorial diameter is 143,000 km. The mass of Jupiter is 318 Me and its mean density 1.31 g/cm^3 .

The surface gravity at its equator is 22.9 m/s^2 . The escape velocity is 59.5 km/s. There are (16+ings) known satellites of the Jupiter.

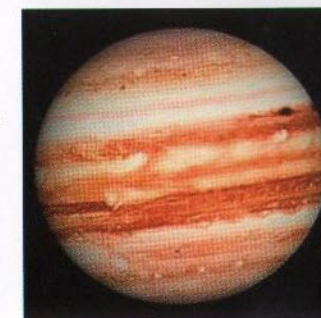
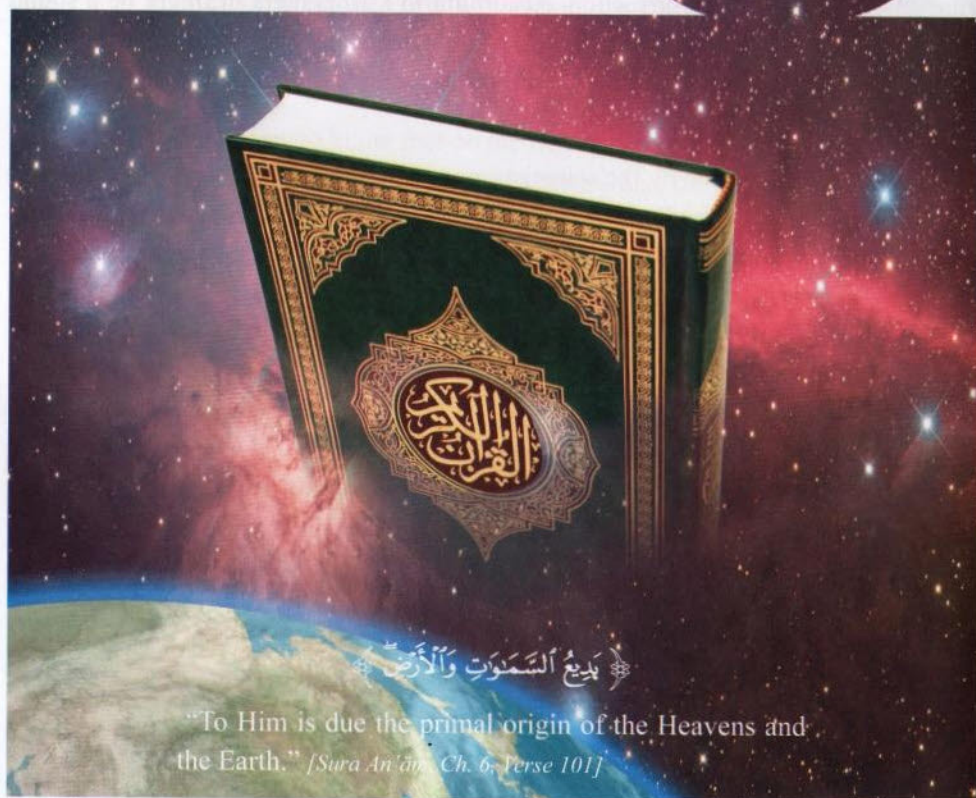


Figure 3.7 Jupiter

Origin Of The Universe And The Holy Qur'an

8



ORIGIN OF THE UNIVERSE

The Big Bang theory came in the second half of the twentieth century to explain the origin of the Universe. According to Einstein's general theory of relativity, the space-time began at the Big Bang singularity and would come to an end at the Big Crunch singularity. General relativity and hence, the standard Big Bang theory is not a quantum theory, therefore, it cannot be entirely correct theory. In order to understand how quantum mechanics may affect the Big Bang and Big Crunch singularities, it is necessary, first, to understand the Hot Big Bang Model. In this model it is assumed that the universe is described by the Friedman's model, right back to the Big Bang. In such models we find that the universe is expanding and as a result any matter or radiation in it is getting cooler.

If we include quantum theory of elementary particles in the Hot Big Bang model then there is brief episode of inflation after the Big Bang, where a small bubble of space-time expands much faster than the speed of light. Therefore the current cosmological standard model is the Big Bang model, with "inflation" as an extension.

According to standard Big Bang model of cosmology, the universe originated 13.7 billion years in the past from a singularity in the Big Bang itself. At the Big Bang, the universe was filled with particles and radiation of nearly infinite temperature and density, followed by a rapid expansion (inflation) of the universe. According to this

Note: The motion of the observer causes a change in the number of waves received per second.

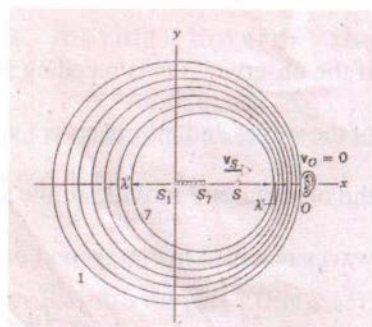


Figure 3.14

Case II- When the source is moving and the observer is stationary.

(a) When the source is moving towards the stationary observer:

If the source is moving towards the observer with velocity v_s (Figure 3.14), then in one second, the waves are compressed by an amount known as Doppler shift represented by $\Delta\lambda$ and is given by

$$\Delta\lambda = \frac{v_s}{v}$$

The compression of waves is due to the fact that same numbers of waves are contained in a shorter space depending upon the velocity of the source. Hence, the wavelength of the sound arriving at the observer is not λ but is λ' and is given by

$$\lambda' = \lambda - \Delta\lambda \text{ (Shorter wavelength)}$$

$$\text{or } \lambda' = \frac{v}{v} - \frac{v_s}{v} = \frac{v - v_s}{v} \dots\dots\dots 3.7$$

The modified frequency increases and is given by

$$v' = \frac{v}{\lambda'} = \frac{v}{\frac{v - v_s}{v}}$$

$$v' = v \left(\frac{v}{v - v_s} \right) \dots\dots\dots 3.8$$

or

$$v' = v \left[\frac{1}{1 - \frac{v_s}{v}} \right] \dots\dots\dots 3.9$$

Result:

From this equation it is clear that $v' > v$. In other words, the pitch (frequency) of sound heard by the observer will increase.

(b) When the Source is moving away from the Stationary Observer:

If the source is moving away from the stationary observer with the velocity v_s , there will be increase in the wavelength and is given by

$$\begin{aligned} \lambda' &= \lambda + \Delta\lambda \\ &= \frac{v}{v} + \frac{v_s}{v} = \frac{v + v_s}{v} \dots\dots\dots 3.10 \end{aligned}$$

The modified frequency decreases and is given by

$$v' = \frac{v}{\lambda'} = \frac{v}{\frac{v + v_s}{v}}$$

or

$$v' = v \left(\frac{v}{v + v_s} \right) \dots\dots\dots 3.11$$

$$v' = v \left[\frac{1}{1 + \frac{v_s}{v}} \right] \dots\dots\dots 3.12$$